AN AUTOMATED DATA SYSTEM FOR EMERGENCY METEOROLOGICAL RESPONSE

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DISCLAIMER

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ABSTRACT

To improve the meteorological data available in case of an accidental radioactive release to the atmosphere, and to conduct research on transport and diffusion processes in the atmosphere, a series of high-quality meteorological sensors have been located on towers in and about the Savannah River Plant (SRP). These towers are equipped to measure temperatures, winds, and turbulence. Signals from the meteorological sensors are brought by land-line to the Savannah River Laboratory (SRL) Weather Center-Analysis Laboratory (WC-AL) where a Weather Information and Display (WIND) minicomputer system has been installed.

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The WIND system consists of a minicomputer with graphical displays in WC-AL and SRP's Emergency Operating Center (EOC). In addition, data from standard weather teletype services provide both routine surface weather observations and upper air wind and temperature observations for the Southeastern United States.

Should there be an accidental release to the atmosphere, the available data and computer codes allow the calculation and display of the location, time, and downwind concentration of the release. Data and calculations are made available to decision makers in near real-time to permit rapid decisive action to limit the consequences of such accidental releases. The emergency response capabilities of the system can also be extended to more general offsite use, such as providing assistance to Department of Energy Savannah River Operations Office personnel for fulfilling their responsibilities for general radiological assistance in the Southeast.

INTRODUCTION

The Savannah River Plant (SRP), managed and operated by the E. I. du Pont de Nemours and Company for the U.S. Department of Energy (DOE), is located in western South Carolina along the Savannah River about 40 km southeast of Augusta, Georgia. Small amounts of radioactive nuclides are released to the atmosphere as a consequence of SRP's mission as the chief producer of radionuclides for DOE. The potential for accidental releases to the

atmosphere exists, although the probability is low. The Savannah River Laboratory (SRL) has as its primary objective the performance of research and process development in support of SRP operations. As a part of this support, SRL is conducting research in the environmental sciences to improve SRL's ability to respond in a meaningful way to accidental releases to the atmosphere. Much of this research may be applied to the general problem of predicting effects from an accidental release of a pollutant. The objective of this research is to develop, test, and use mathematical models for evaluating transport, dispersion, and effects of materials released to environmental systems such as the atmosphere, streams, river, estuary, ocean, soils, plants, and ground water, and to apply these models to problems of relevance to SRP and the energy industry of the Southeastern United States.

To aid in the evaluation of releases to the atmosphere, high quality weather instruments have been placed on a nearby television tower and on towers in the seven primary operating areas of SRP. In addition, a minicomputer with graphical displays has been installed for research, for establishing archives of meteorological data, and for rapid calculation of paths and effects of accidental releases to the atmosphere. This latter item directly supports the SRP Emergency Operating Center (EOC). The system, consisting of the minicomputer and inputs from the meteorological sensors, is called the Weather Information and Display (WIND) System. It is the WIND system and its output to the EOC that will be described in this paper.

METEOROLOGICAL INSTRUMENTATION AT SRP

A television tower within 15 km of the plant boundary is instrumented at seven levels between 2 and 304 m above the ground surface with temperature sensors and turbulence quality wind sensors. The wind sensors are commercially available wind measuring instruments with bivanes (horizontal and vertical wind direction indicators) and fast-response cup anemometers with time constants of about one second. The time response of the associated platinum resistance thermometers is about 45 seconds. See Reference 1 for more details.

Adjacent to main SRP operating areas, seven 62-m high towers were erected in nearby pine forests. The 62-m height equals the stack heights in these operating areas. Mounted on each tower is a commercially available vector vane wind sensor which measures and transmits horizontal and vertical wind directions and total wind speed data. The time response of these instruments is less than one second. The locations of the TV tower, the seven SRP towers, and the Weather Center-Analysis Laboratory (WC-AL) can be seen in Figure 1.

In addition, an acoustic sounder provides continuous real-time measurements of the vertical mixing characteristics of the lowest 1 km of the atmosphere. The acoustic sounder provides information from within this layer concerning buoyant plumes (thermals), inversions, and depth of the well-mixed layer. The

data are recorded in the WC-AL for storage and for subsequent computer processing.

The WC-AL also has a National Facsimile Circuit, which prints out large-scale observations and forecasts from the National Weather Service; an FAA Teletype Service A Teletype receiver, providing hourly surface weather observations and some forecasts; and a National Weather Service C Teletype receiver, providing upper air and surface synoptic information.

WEATHER INFORMATION AND DISPLAY (WIND) SYSTEM

A PDP 11-40 (Digital Equipment Corp., Maynard, Mass.) minicomputer has been installed within the WC-AL. This system consists of a central processor, a 128,000 word high-speed memory, three 1.2 million word disk drives, a 20 million word disk drive, two 126,000 word floppy disk drives, and a magnetic tape drive compatible with the SRL IBM-360/195 computer (International Business Machines, Armonk, N.Y.). Input channels collect meteorological data from the TV tower, the seven-tower system, and both teletype services. The minicomputer drives graphical display units both at the WC-AL and within the SRP Emergency Operating Center (EOC). This system is shown schematically in Figure 2.

Computer terminals, which receive the same or similar displays as received by the EOC, soon will be installed in each of SRP's operating areas. The need for immediate action in the area itself is paramount. And the area terminals would be tailored

to the area's need and provide information necessary for immediate consequence-limiting decisions. A prototype terminal has already been installed and is operating successfully in the Heavy Water Facility.

The WIND system is linked to the JOSHUA system* as a graphics terminal. This configuration enables the transmission of current meteorological data to the IBM-360/195 from WIND so that more sophisticated meteorological models than currently in the WIND system could be used to predict atmospheric behavior.

The WIND system is used to perform environmental research, to store meteorological data in a summarized form for processing with the SRL IBM-360/195 computer, and to provide a real-time system to support emergency response at the SRP site.

DOE is evaluating a means of assisting the management at key DOE nuclear sites in responding to accidental releases to the atmosphere. With DOE support, the Lawrence Livermore Laboratory (LLL), University of California, has developed a service to provide sites with real-time predictions of the consequences of an atmospheric release of toxic emissions. The service is called Atmospheric Release Advisory Capability (ARAC).[3]

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* The JOSHUA system is a computer operating system developed at SRL to provide a data base operating system not available with the IBM operating system for the 360 series computer. The JOSHUA operating system provides the capability to develop modular data based computational systems for large-scale multi-step iterative calculations oriented for use with remote terminals.[3]

The ARAC system, while acting as backup to the WIND system at SRP, also provides active support during an emergency. It also is able to provide needed graphics of the status of a release under complex meteorological conditions for longer periods of time (releases traveling long distances and released over long periods of time).

WIND SYSTEM AND EMERGENCY RESPONSE

For a system to support countermeasures for accidental atmospheric releases, it must be able to answer the following questions.

1. What was released?
2. How much was released?
3. Where and when was it released?
4. Where is it going in the environment?
5. What will be the concentrations as a function of distance and time?
6. What will be the effects?

In the WIND system, the first three questions above must be answered by operating personnel. When this information is supplied, and the adequate meteorology is provided, Questions 4 and 5 can be answered directly, and Question 6 can be answered for radionuclides with the appropriate dose calculations.

This is done rapidly by a Menu-type program both available to the Weather Center-Analysis Laboratory and EOC (Figure 3).

After a minimum period of training the personnel that staff the EOC can run these programs in the event of an accidental release. Function No. 1 is a Terminal Check program. This program gives a clear display when the system is functioning properly.

Function No. 2 of the Menu program gives an up-to-date display of the data from the meteorologically instrumented TV tower wind sensors and seven-tower sensors around SRP. This output uses the latest 15 minutes of data (Figure 4).

Function No. 3 of the Menu program shows the current estimate of release behavior. This gives a quick assessment of a potential release and allows the EOC Staff to take some preliminary action while getting ready to run the more sophisticated programs that follow (Figure 5). The map in Figure 5 is sent to the EOC each hour based on the most recent determination of the average wind turbulence, and temperatures of the last hour. The dispersion of pollutants in the atmosphere are calculated using simple Gaussian puff and Gaussian plume equations. In addition, the map displays trajectories and the extent of the dispersion as calculated from time-dependent two-dimensional wind fields. Presently, the system works either by assuming a unit release and latest available meteorological conditions or in a query-response mode whereby the WIND minicomputer asks certain questions and, when supplied with the answers, provides graphical output (see function 5). This provides the EOC a ready map of the path of possible releases to the atmosphere based on the latest meteorological condition. It

also provides a check on the operability of the console and hard copy unit located in the EOC.

Function No. 4 produces the estimated radioactive accident integral gamma dose. The program supplies tabular calculations on the gamma radiation dose from noble gases that would be released during a reactor core meltdown.

When Function No. 5 has been requested, the program will provide tabular and graphical outputs (Figure 6a-6g). The tabular information is self-explanatory. Three maps are given automatically. The last one covers the area of responsibility of the DOE Savannah River Operations Office (1600 km on a side, Figure 6g). The next is a smaller area, 630 km on a side centered about the source location (Figure 6f) and the first map is a yet smaller area, 160 km on a side (Figure 6e). All three figures depict a simulated release from the F Area with the circle centered on the location at the end of each hour of travel of the puff (an instantaneous release of material to the atmosphere). The circle radius represents a two-sigma deviation from the centerline concentration which for Gaussian distribution would include 90% of the material in a puff.

Comparing these maps with Figure 6d, it is possible to know the centerline concentration at the end of each hour plus the concentration value at the two-sigma distance and their location. This information provides SRP personnel with the information necessary to decide what consequence-limiting action, if any, need

be taken. The overall program from start to finish only takes several minutes for an accomplished operator. Many of the meteorological parameters are obtained automatically if the latest data are all that need be used.

Function No. 6 is the forerunner of programs that will be sent to each operation area. This function at present issues a map centered on the D-Area Heavy Water Production Area (Figure 7). Concentration isopleths are shown for a continuous release (plume) from the 400-ft tower in that area. The map is also sent to D Area each hour via a Tektronix Display Terminal. Proper use of this display would allow personnel to take emergency action in case of an accidental H_2S release.

SUMMARY

SRP's Weather Information and Display System is capable of producing useful and timely support for predicting effects of accidental releases to the atmosphere, and is also capable of performing calculations and data storage for research purposes. This system is capable of expansion to meet the needs of the emergency decision maker and the individual research scientist, and to support pathways other than the atmospheric pathways (e.g. releases to rivers and streams of radionuclides or other elements).

REFERENCES

1. T. V. Crawford. "Facilities for Atmospheric Science Research." *Progress Report Dose-to-Man Program FY-1973.* USAEC Report DP-1341, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC (1974).

2. *JOSHUA System.* USERDA Report DP-1380, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, SC (1975).

3. M. R. Dickerson and R. C. Orphan. "Atmospheric Release Advisory Capability." *Nuclear Safety 17* (3), May-June (1976).

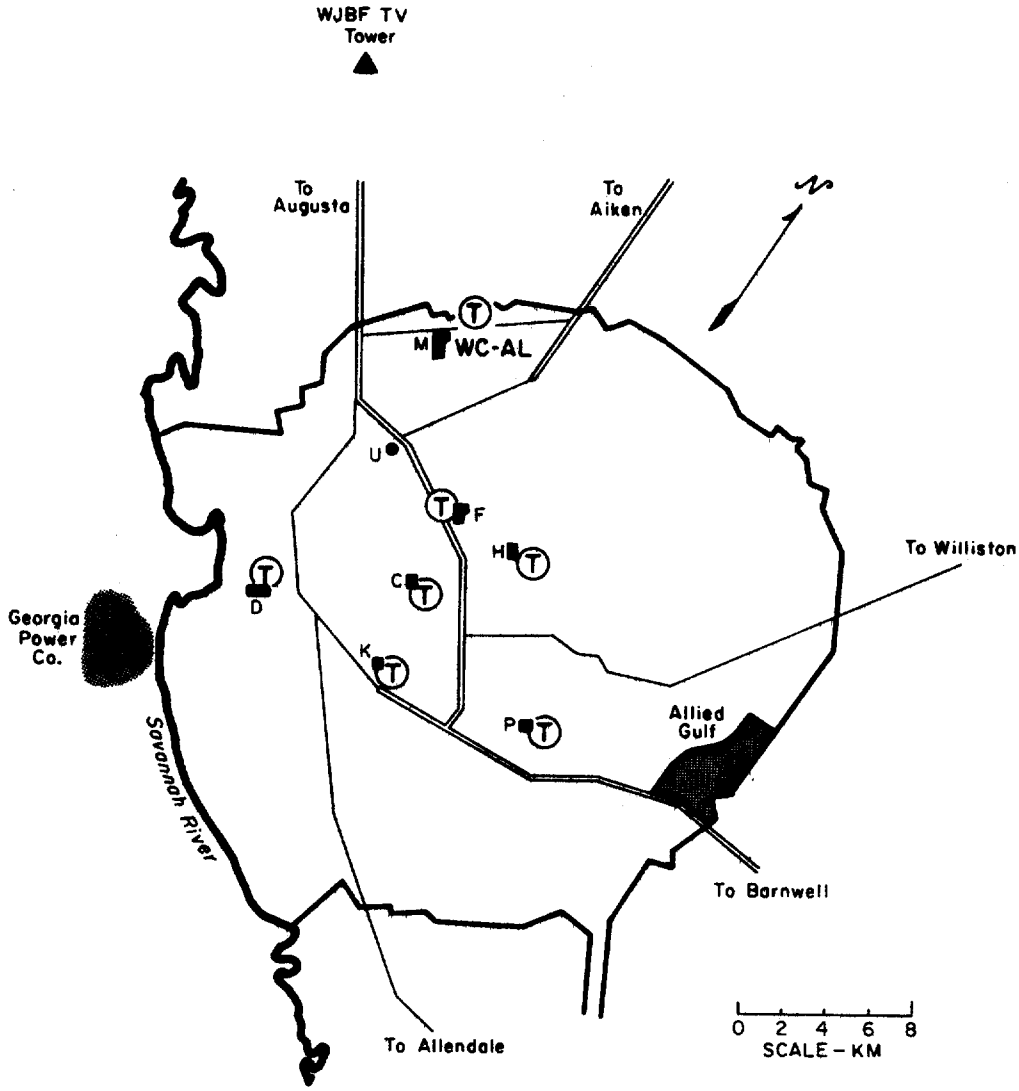

FIGURE 1. Locations of the Seven Area Meteorological Towers, the WJBF-TV Tower, the Weather Center Analysis Laboratory (WC-AL), and the Acoustic Sounder (U)

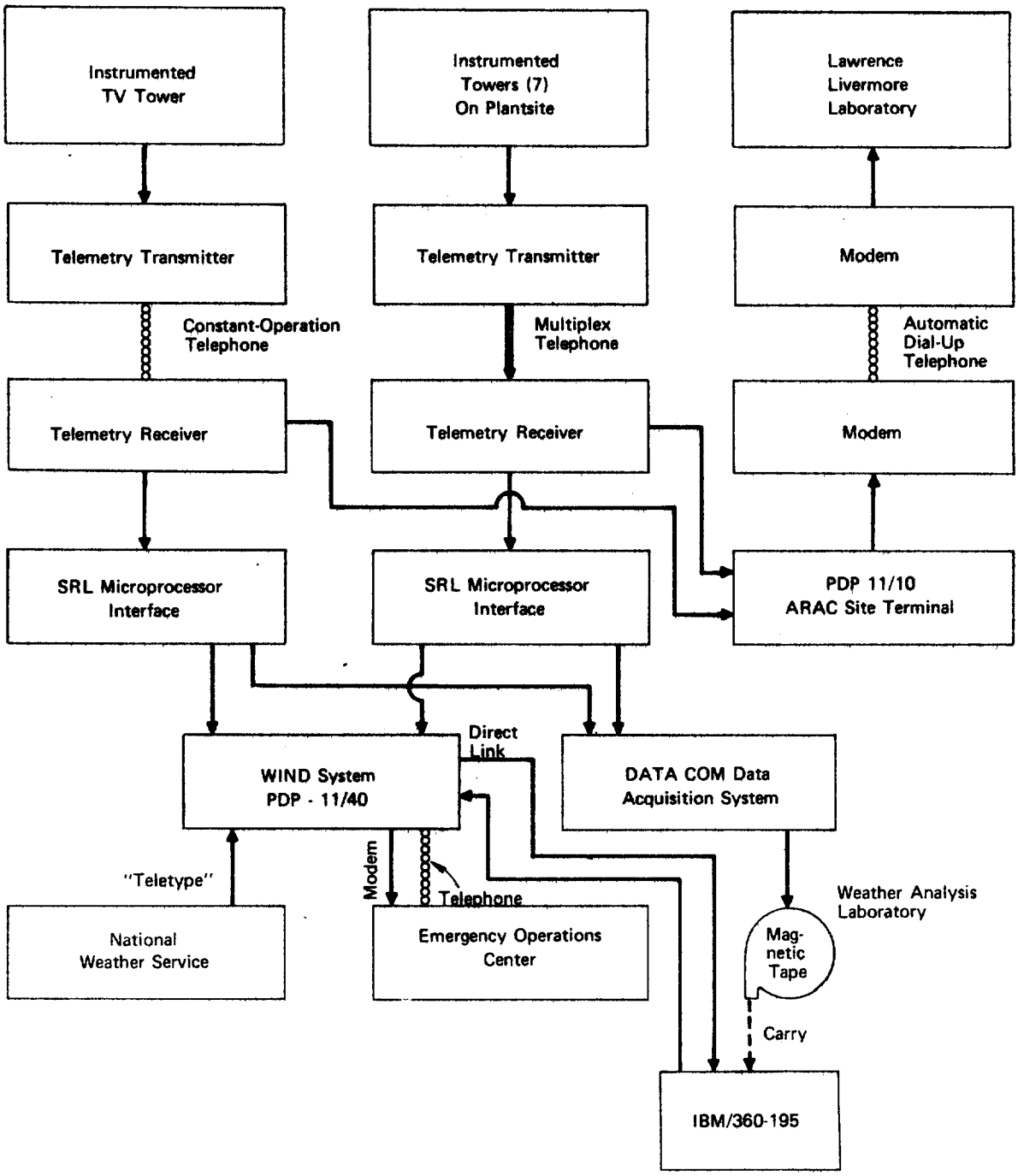

FIGURE 2. Schematic Representation of the WIND System and the ARAC Site Terminal

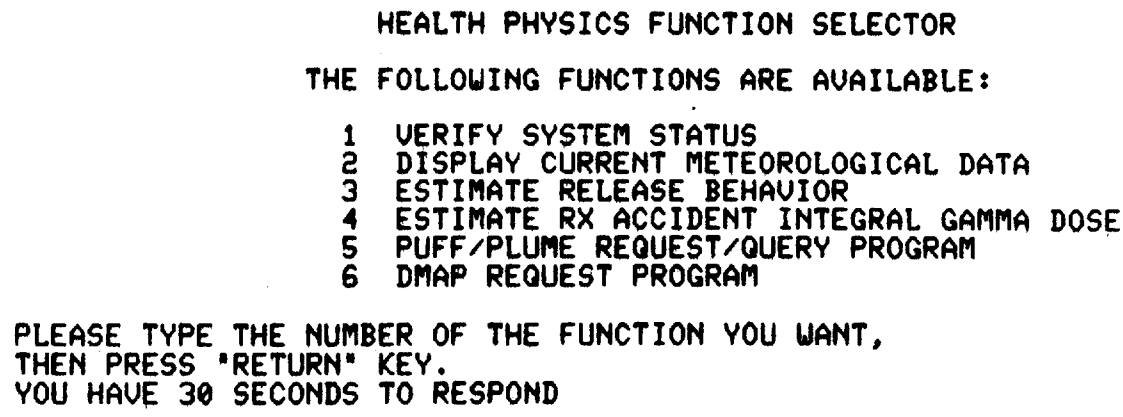

FIGURE 3. The Menu-Select Program[a]

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a. This lists the six programs that are available for use of emergency operating personnel and personnel within the WC-AL.

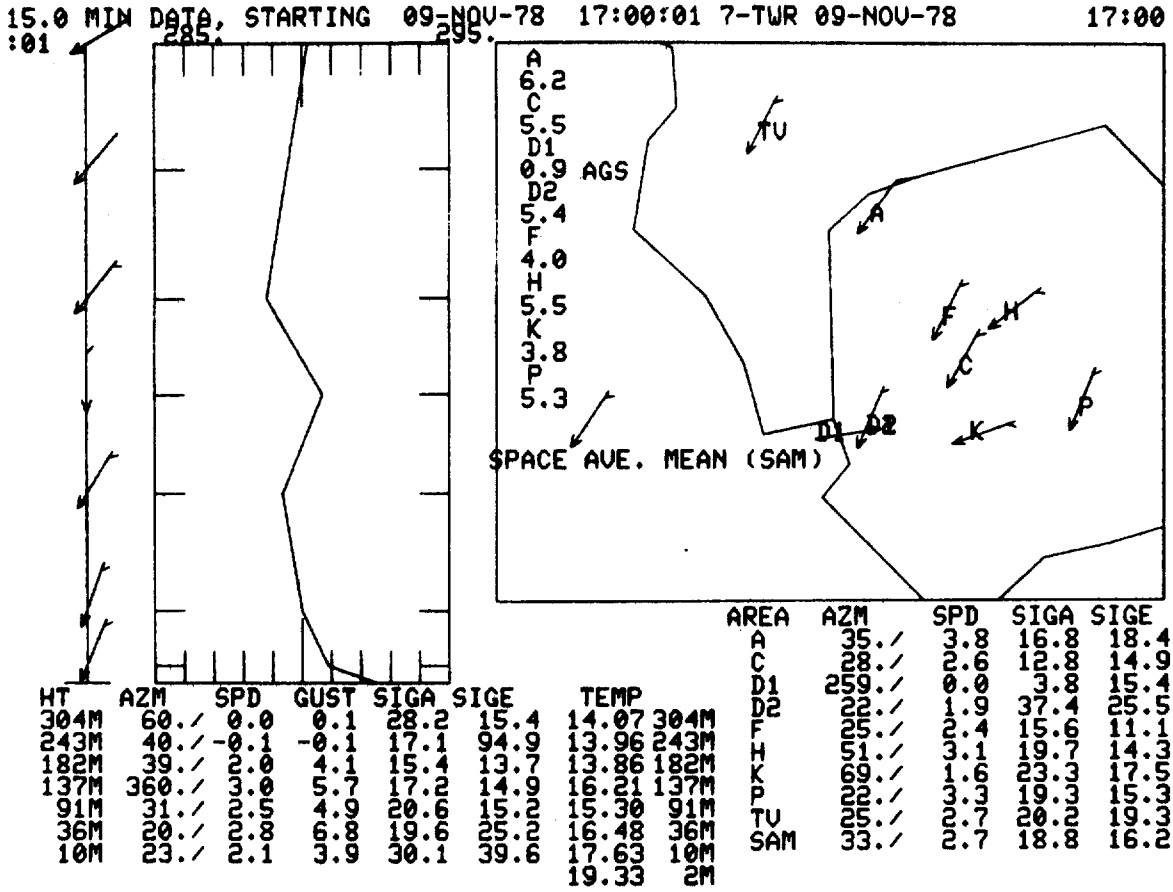

FIGURE 4. Graphical Summary of Latest Meteorological Conditions[a]

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a. This output, from Selecting Menu item 2, is compiled from the TV tower and seven plant towers. The extreme left half of the figure represents the TV tower; arrows show wind direction as a function of height on the tower. Barbs on each arrow give a visual indication of wind speed with a whole barb equal to 5 m/sec, half-barb 2.5 m/sec. The graph (left center) displays absolute temperature with respect to the base of the TV tower in units of degrees Kelvin. A vertical line on this graph indicates a neutral atmosphere, a line slanting to the right a stable atmosphere, a line slanting to the left an unstable atmosphere. The table under the graph contains these data in tabular form. The right half shows wind conditions over the SRP site. The vector average of all good data at the 62-m heights is displayed as space average mean (SAM). The column on the left half of the map indicates the wind gusts at each of the indicated areas.

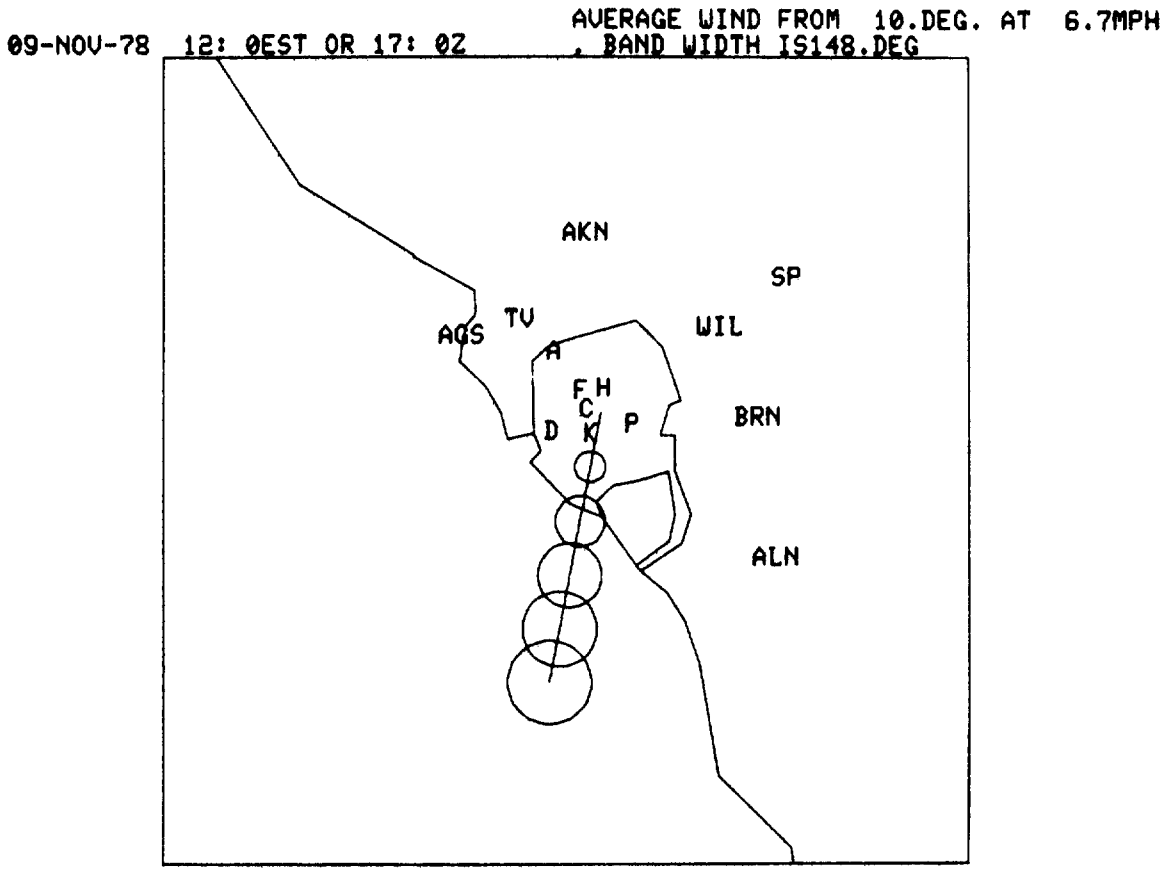

FIGURE 5. Output Page 3 of Selecting Menu Item 3[a]

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a. This is a map of the plant site showing the Savannah River, the plant sites, the operational areas (labeled A, C, D, F, H, K, and P), the TV tower and some nearby towns with AGS being Bush Field, Augusta, Georgia, AKN being Aiken, SP being Springfield, S.C., WIL being Williston, S.C., BRN being Barnwell, S.C., and ALN being Allendale, S.C. This program uses the latest wind whose day-time group is given in the upper left-hand part of the figure and is shown on the right-hand side in degrees from which the wind is blowing. Wind speed is in statute miles/hr. The circles are located 1 hour apart on the path and have a radius of 2 standard deviations (SIGY).

```
 LATEST WINDS TO BE USED? TYPE YES OR NO
  -NO MEANS MANUAL INPUT OF WINDS AND MET DATA

 HARD COPY NEEDED?TYPE YES OR NO
YES
 TYPE'PF' FOR PUFF OR 'PL' FOR PLUME, THEN HIT RETURN.
IF RELEASE IS LONGER THAN  6.2 MINS. TYPE PL
PF
 TYPE TIME AND DATE OF INITIAL RELEASE, EX= 1635 03/07/75
1635 11/09/78
 IS THIS FOR A RADIOACTIVE RELEASE?, YES OR NO
YES
 ISOTOPE FOR DOSE FACTORS
TYPE PU39 FOR ALPHA(PU)
TYPE CF52 FOR CALIF. 252
TYPE CM44 FOR CURIUM 244
TYP3 I131 FOR IODINE 131
TYPE FP   FOR FISSION PROD(RU)
TYPE C060 FOR COBALT 60
TYPE HTO  FOR TRITIUM
OR HIT RETURN FOR NO ISOTOPE
```

FIGURE 6.a. Output Page 1 of Selecting Menu Item 5[a]

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a. This is a query response program. In this case it was desired to use the latest meteorology; however, the output on this program can cover 12 hours, with each hour average wind input by the terminal operator. It asks whether it is a radioisotope release. In this case the answer was yes; however, should the answer have been no, then chemical releases for chlorine, hydrogen sulfide, or sulfur dioxide would have been requested in order to calculate the downwind concentration in parts per million. Seven different isotopes have the dose conversion constants incorporated into the program. Response in this case is for a tritiated water vapor release.

```
TYPE SOURCE RATE IN CI, DEFAULT IS 1. CI
 STACK HEIGHT IN METERS, DEFAULT IS 65. METERS
 HEIGHT OF INVERSION IN METERS, DEFAULT IS 500.
SOURCE LOCATION  AT SRP?, TYPE YES OR NO'DEFAULT IS YES
SOURCE LOCATION,AA FOR A AREA,CC,DD,FF,HH,KK,PP
  ARE AVAILABLE, DEFAULT IS KK FOR K AREA
FF
```

FIGURE 6.b. Output Page 2 of Selecting Menu Item 5[a]

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a. Questions are asked as to location, source rate, height, etc.

```
THE FOLLOWING DATA CAN BE USED TO DETERMINE THE  GROUND LEVEL
CONC.  AT CLOUD CENTERLINE AS A FUNCTION OF TIME AND TRAVEL
DIST.  ALSO PRESENTED IS THE CONC. AT A DIST. EQUAL TO 2
SIGY FROM THE CLOUD CENTERLINE.  THE INPUT DATA CONSIST OF
HOURLY AVERAGE WIND DATA. A MAX. OF TWELVE HOURS OF DATA IS
INPUT BUT OUTPUT IS COMPUTED EVERY 10 MIMUTES.


SOURCE TERM IS    1.0E 12PICI       HALFLIFE IS   1.0E 10

STACK HEIGHT IS  65.0 M MAXIMUM MIXING DEPTH IS  500.0 M

START TIME IS 1635 DATE=11/09/78
INITIAL WIND IS FROM  10.3DEG AT  2.99M/SEC
NO PARTICULAR RADIOACTIVE ISOTOPE IS BEING USED
```

FIGURE 6.c. Output Page 3 of Selecting Menu Item 5[a]

---

a. This page presents some of the initial information input as a check on the data which have been entered.

DIST(KM)	T(HR:MIN)	SIGY(KM)	DOSE-REM	C/L CONC	2-SIG CONC	TYPE
1.8	16:45	0.30	2.27E-06	9.15E 03	1.24E 03	PF
3.6	16:55	0.55	1.01E-06	2.21E 03	2.99E 02	PF
5.4	17: 5	0.80	5.98E-07	8.86E 02	1.20E 02	PF
7.2	17:15	1.05	4.09E-07	4.64E 02	6.28E 01	PF
9.0	17:25	1.28	3.07E-07	2.85E 02	3.86E 01	PF
10.8	17:35	1.50	2.44E-07	1.94E 02	2.63E 01	PF
12.5	17:45	1.69	2.02E-07	1.42E 02	1.93E 01	PF
14.3	17:55	1.87	1.72E-07	1.10E 02	1.49E 01	PF
16.1	18: 5	2.04	1.50E-07	8.79E 01	1.19E 01	PF
17.9	18:15	2.19	1.33E-07	7.25E 01	9.81E 00	PF
19.7	18:25	2.33	1.20E-07	6.11E 01	8.27E 00	PF
21.5	18:35	2.47	1.09E-07	5.24E 01	7.10E 00	PF
23.3	18:45	2.60	1.01E-07	4.64E 01	6.29E 00	PF
25.1	18:55	2.72	9.67E-08	4.24E 01	5.74E 00	PF
26.9	19: 5	2.83	9.27E-08	3.90E 01	5.28E 00	PF
28.7	19:15	2.95	8.92E-08	3.61E 01	4.89E 00	PF
30.5	19:25	3.05	8.61E-08	3.36E 01	4.55E 00	PF
32.3	19:35	3.15	8.33E-08	3.15E 01	4.26E 00	PF
34.1	19:45	3.25	8.08E-08	2.96E 01	4.01E 00	PF
35.9	19:55	3.35	7.85E-08	2.79E 01	3.78E 00	PF
37.6	20: 5	3.44	7.64E-08	2.64E 01	3.58E 00	PF
39.4	20:15	3.53	7.44E-08	2.51E 01	3.40E 00	PF
41.2	20:25	3.62	7.26E-08	2.39E 01	3.24E 00	PF
43.0	20:35	3.70	7.10E-08	2.28E 01	3.09E 00	PF
44.8	20:45	3.79	6.94E-08	2.18E 01	2.96E 00	PF
46.6	20:55	3.87	6.79E-08	2.09E 01	2.83E 00	PF
48.4	21: 5	3.95	6.66E-08	2.01E 01	2.72E 00	PF
50.2	21:15	4.03	6.53E-08	1.93E 01	2.62E 00	PF
52.0	21:25	4.10	6.41E-08	1.86E 01	2.52E 00	PF
53.8	21:35	4.18	6.29E-08	1.80E 01	2.43E 00	PF

ALL CONCS ARE GROUND LEVEL PCI/M**3)

FIGURE 6.d. Known Isotope, Output Page 2, Selecting Menu Item 3[a]

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a. In this case since the particular radioisotope is known, then the dose is given in rem. It is assumed that the individual will be at the distance shown and remain at that location for the entire passage of the puff. The two concentration columns are in picocuries per cubic meter since the actual source is known. There would be two more pages taking the total travel time to twelve hours.

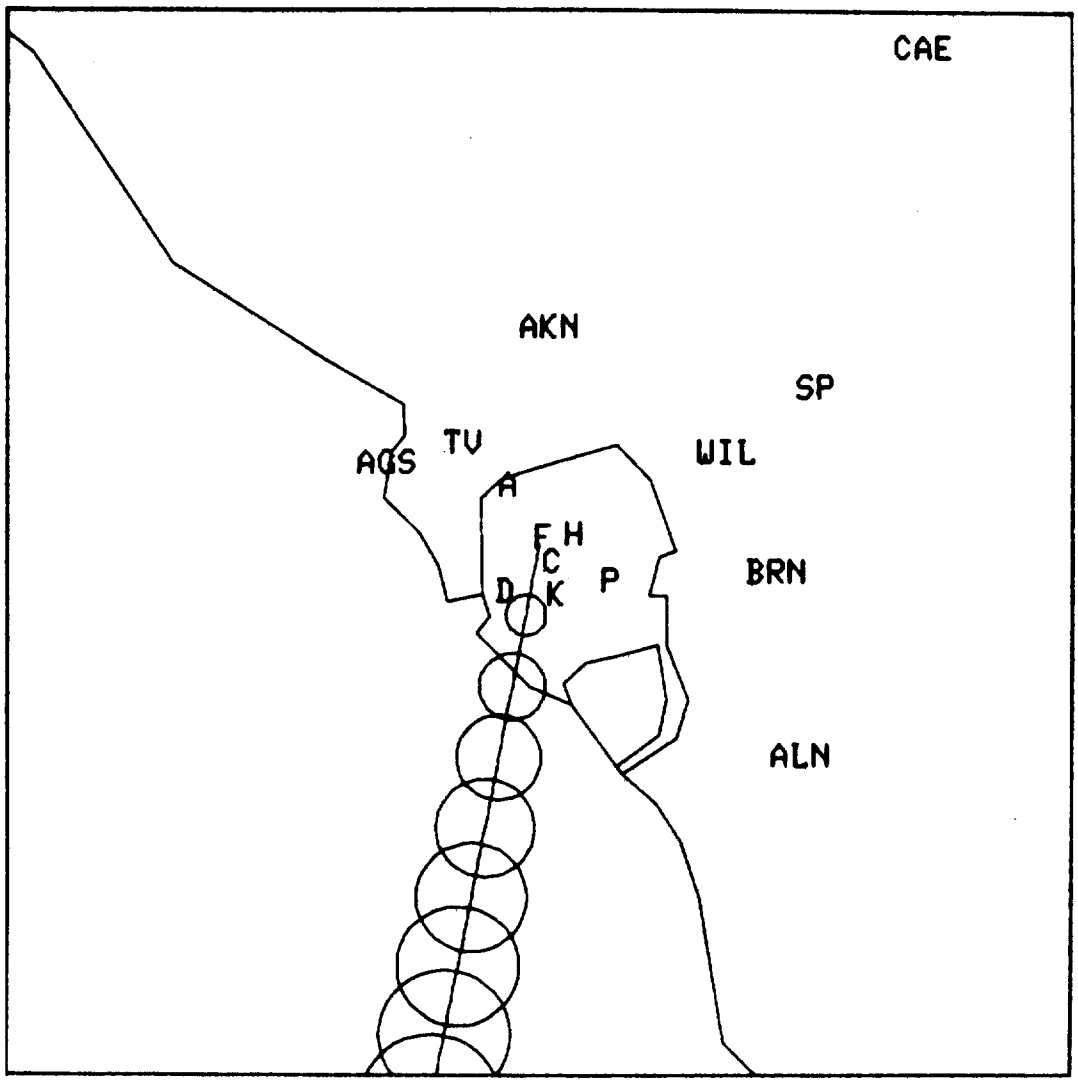

FIGURE 6.e. Travel for 12 Hours, Page 3 of Selecting Menu Item 3[a]

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a. This is a map of the same scale as shown in Figure 5, and the same conditions, except that the travel is shown for only up to 12 hours of travel time.

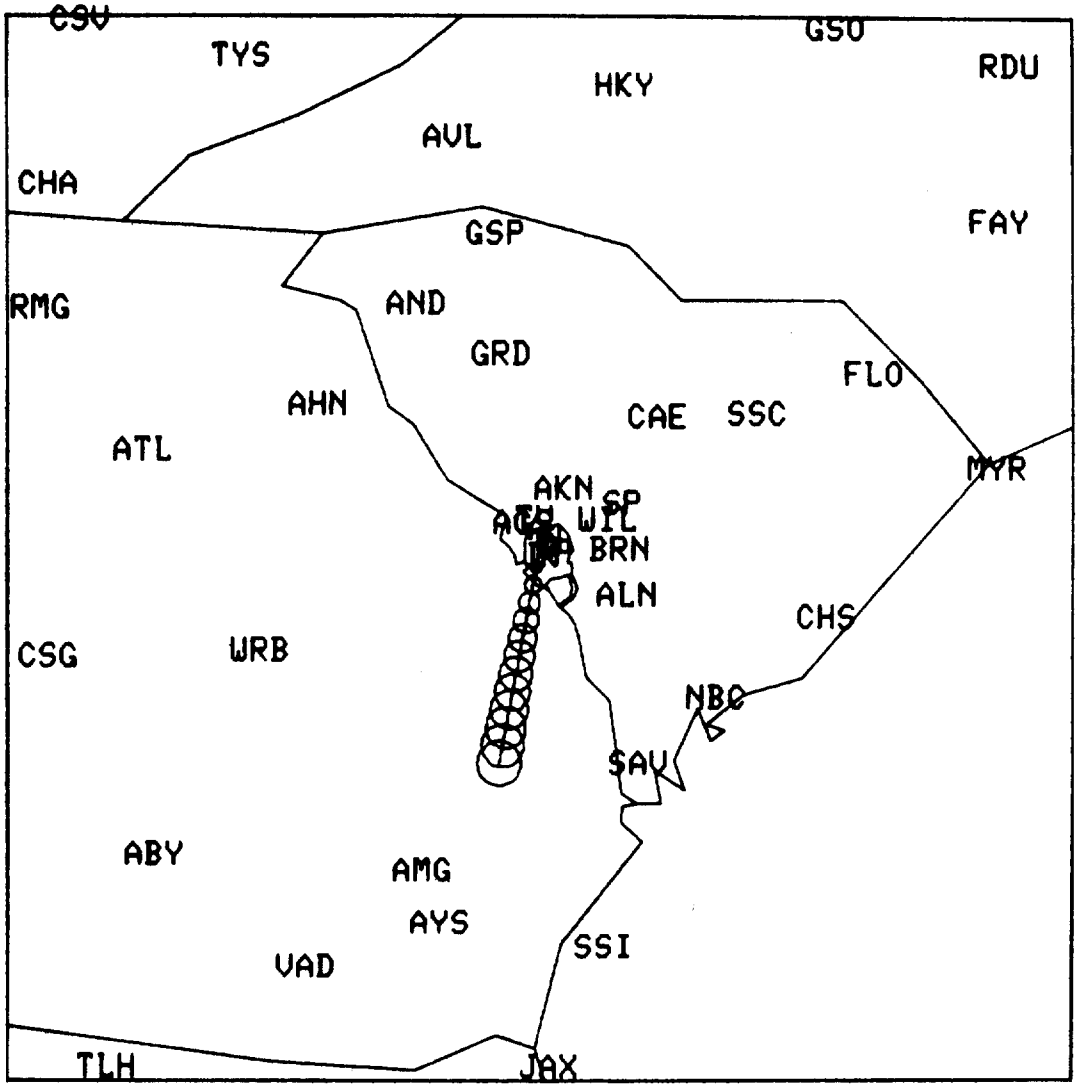

FIGURE 6.f. Large View of Release Trajectory[a]

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a. This is a larger view of the release trajectory which covers South Carolina and portions of Georgia, Tennessee, and North Carolina. The three-letter symbols are the standard symbols for cities in the United States.

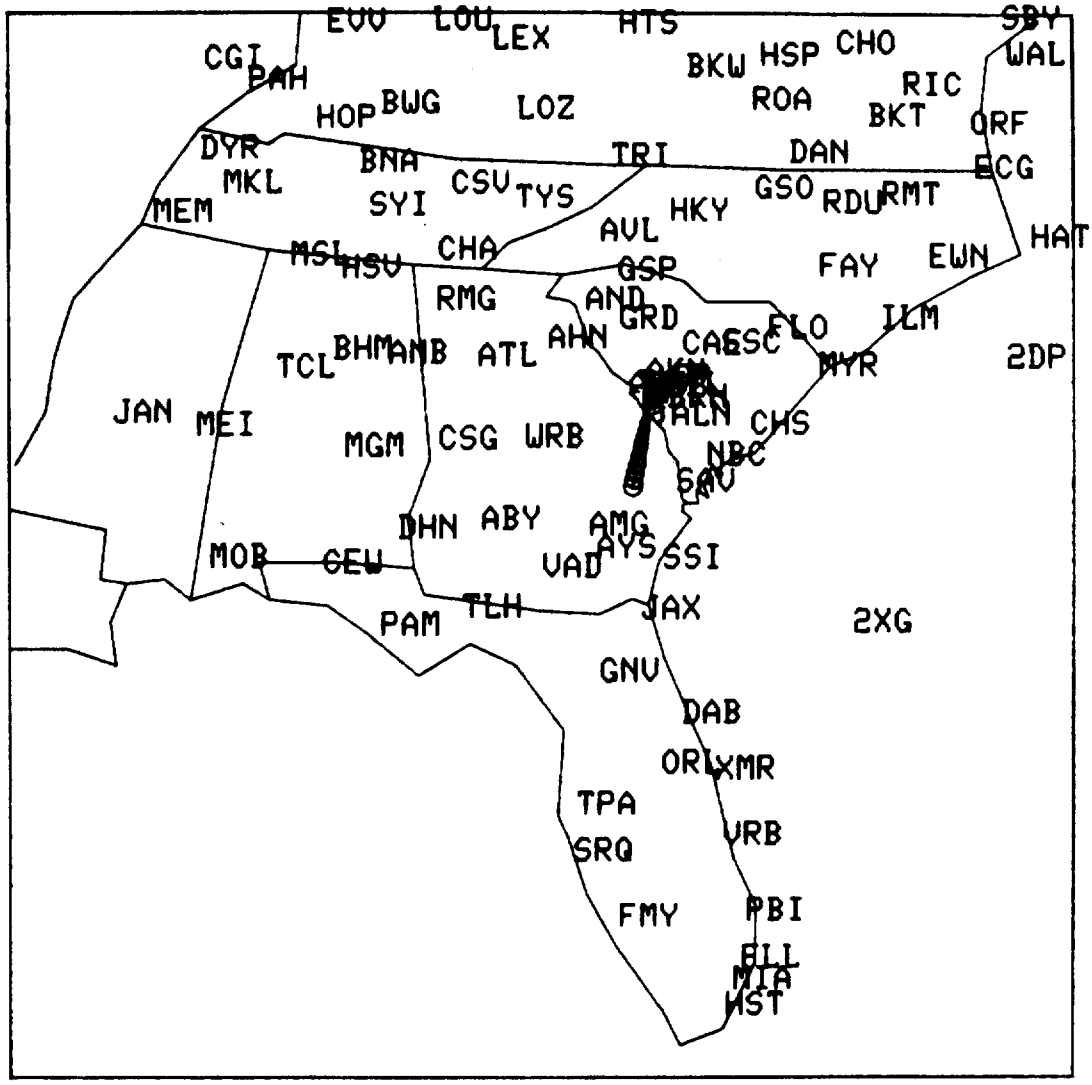

FIGURE 6.g. Area of Responsibility for Savannah River Operations Office[a]

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a. This shows the states of interest to the Savannah River Operations Office area responsibility; i.e. North Carolina, South Carolina, Georgia, Alabama, and Florida.

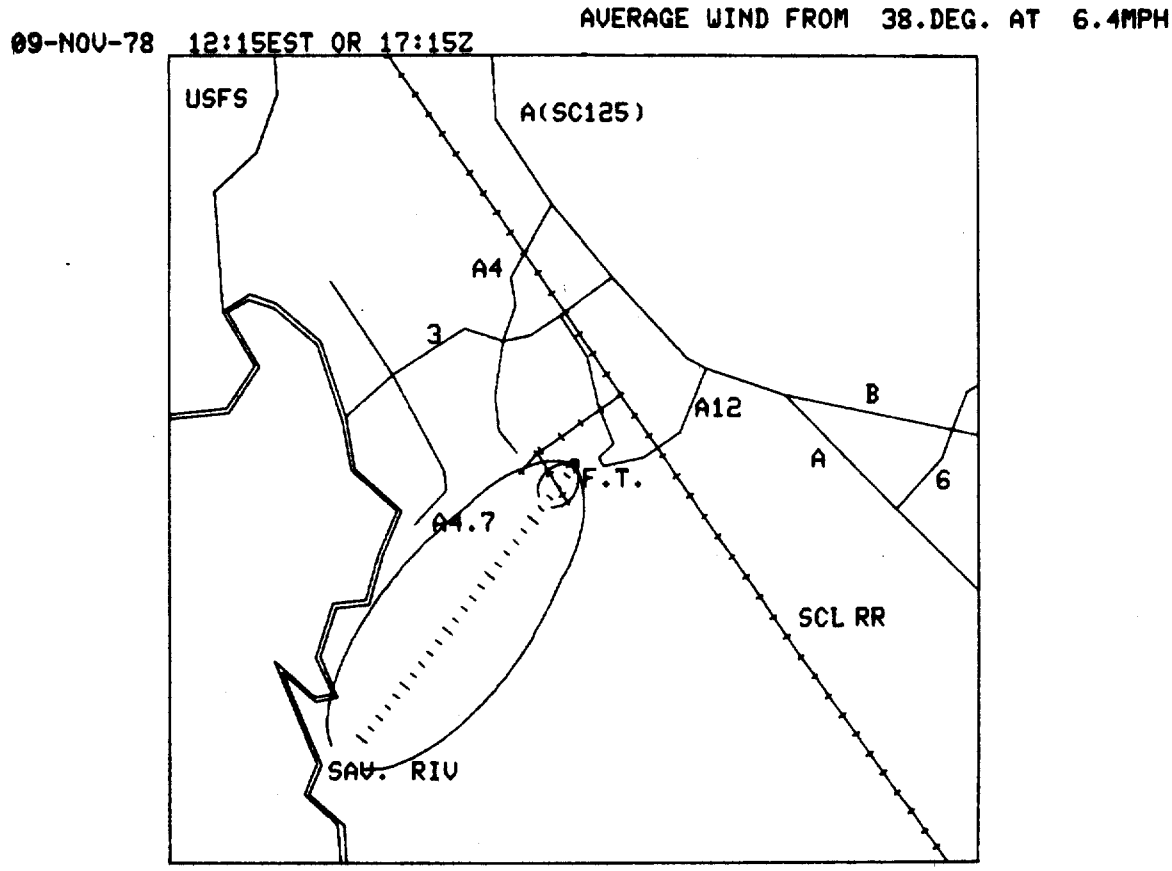

FIGURE 7. Output from Selecting Menu Item 6[a]

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a. This is the output from Menu item 6. This map centers on the heavy water production area. The latest meteorology is given at the top of the figure. The plume centerline shows crosslines for each minute of travel time. Three isopleths are plotted with the innermost isopleth barely visible just at the stack, where the ground concentration is 100 ppm. The next isopleth is 10 ppm, and the outermost isopleth is 1 ppm for a release of 1 ton per minute of hydrogen sulfide. (The top of the production towers is a 40-meter release height.)